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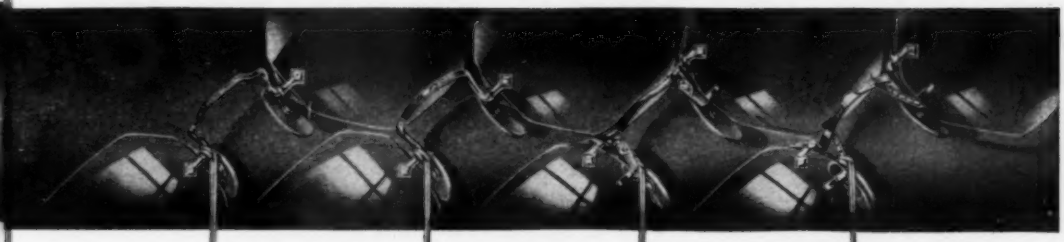

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AMERICAN JOURNAL OF OPTOMETRY

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NUTRITIONAL FACTORS PRODUCING CATARACTS*

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Cataract has been defined by various authorities as any pathological condition in which the normal transparency of the lens is altered. The change is probably due to a coagulation of the lens protein. There is usually, also, a deposition of cholesterol and calcium salts. Changes in the physical and chemical state of the lens protein may be brought about by a number of factors. Hydrogen-ion concentration, disturbance of osmotic equilibria, and the action of heat and light may be factors in cataract formation. In man, cataract is usually associated with senility. It also occurs in certain diseases among which are diabetes, aparathyroidia, mongolian idiocy, and cretinism. Ingestion of specific poisons, such as ergot and dinitrophenol, have been known to cause cataract. Cataract has been produced experimentally by feeding naphthalene to rabbits and thallium acetate to rats, by removal of the parathyroid glands from rats and dogs, and by dietary deficiencies in different laboratory animals. Any interference with normal metabolic processes may lead to degenerative changes in the lens. General metabolic disturbances may affect the lens by creating a deficiency of some substance required by the lens for normal metabolism, by producing toxic substances, by altering the composition of the aqueous in respect to water, salt, or hydrogen-ion concentration, or by some other means as yet unknown. Cataract is associated with only a limited number of pathological conditions, and in these conditions the factors which act upon the lens and cause the degenerative changes have not yet been identified.

The chief nutritional factors which have been shown to cause cataract in laboratory animals are: (1) deficiency of tryptophane and cystine, (2) vitamin B deficiency, (3) high lactose and galactose diets, (4) removal of parathyroids, and (5) diabetes.

Curtis, Hauge, and Kraybill[1] describe a type of blindness in rats when they fed a diet deficient in tryptophane. This blindness is charac-

*Submitted for publication August 30, 1937.

terized by opaqueness and loss of the characteristic colors of the eye. It is quite different from the ophthalmia associated with vitamin A deficiency. This disorder appears to be entirely due to the lack of tryptophane. Relatively large amounts of the essential amino acids are required for the growth of lens proteins. Lack of cystine in the diet has also been given as the cause of cataract in the tiger salamander.[2]

Day was the first investigator to report cataract as a result of deficiency of the vitamin B_2 complex. He and his associates in a series of studies[3-6] found that young albino rats developed bilateral cataract in from 60 to 90 days on a diet deficient in vitamin B_2. The condition developed in from 92 to 100% of the animals on the deficient diet. The time required for appearance of the lesions was correlated with the growth rate. The greater the growth the less was the probability that cataract would develop. Equally high incidence of cataract was observed in mice and young wild gray rats deprived of vitamin B_2. Cataracts were also observed in chickens and monkeys. Day found that when his animals, suffering from cataract produced by vitamin B_2 deficiency, were given a vitamin-rich diet all general and ocular manifestations cleared up except the cataract. There is no mechanism for the repair of damaged lens fibers.

Bourne and Pyke[7] did not find nearly as high an incidence of cataract on a diet deficient in vitamin B_2 as did Day and his collaborators. The highest percentage observed in their animals was 31% while Day repeatedly observed an incidence of about 90%. Bourne and Pyke found dermatitis a more consistent symptom of the deficiency of the vitamin B_2 complex than the occurrence of cataract.

Yudkin[8] found that vitamin G (B_2) deficiency produced cataract in young rats but failed to do so in older animals. Dogs fed on a diet free of vitamin G failed to develop cataract. Yudkin points out that the incidence of cataract in pellagra is not any greater than in any other disease.

Another dietary factor which has been shown to cause cataract is a high lactose diet. Mitchell and Dodge[9-11] fed rats on a ration high in lactose and found a high incidence of cataract in their animals. They also found a high incidence of cataract in rats fed on a high galactose ration. The cataracts were produced much more rapidly on the high galactose ration than on the high lactose ration. The calcium content of the cataractous lens is always much greater than that of normal lens. In this series of experiments, the calcium content of the cataractous lenses were of the same magnitude on the two sugars but the increase apparently took place in a shorter time in the rats fed galactose. The calcium content of all eyes showing mature cataract was three to four times that of older rats on a control diet of 70% starch.

Slightly higher blood sugars were observed in the rats with cataract. Galactose was observed in the urine, indicating that some of the blood sugar was galactose. It has been found that galactose is highly toxic to

lens epithelium in much lower concentration than either glucose or fructose. If the capsular membrane undergoes even slight degenerative changes in the presence of galactose, it is not surprising that increased permeability of the lens may occur. This would result in a disturbance in the colloidal structure of the lens.

Yudkin and Arnold[12] corroborated the findings of Mitchell and co-workers on the effects of high lactose and high galactose rations. They produced cataracts on a high percentage of their rats on the high lactose and galactose diets. Morgan and Cook[13] were also able to produce cataract in rats on high lactose diets.

Day[14–15] studied the blood sugar in rats in which cataract had been produced by a vitamin G deficient diet and by diets containing lactose and galactose. Rats receiving galactose and lactose showed higher blood sugar levels than those on other carbohydrates. As in Mitchell's experiment, the animals fed galactose developed cataract first and also gave a higher blood sugar. There was no increase in blood sugar in cataract produced by vitamin G deficiency. In fact, such animals showed a slightly lower blood sugar than animals on a normal diet.

Cataract has been frequently associated with calcium metabolism. The amount of calcium in cataractous lenses is greatly increased. Clinically, cataract is frequently associated with diseases involving a disorder of calcium metabolism. It occurs after hypoparathyroidism, in idiopathic hypoparathyroidism, and in rickets. It has been produced experimentally by the removal of the parathyroid glands in rats and dogs[16–17]. Cataract also occurs in association with tetany, both endemic and post-operative.

Cataract is also associated with diabetes. There is no evidence as to whether the carbohydrate metabolism of the lens is affected by this disease. Probably the factors involved are chiefly physicochemical. Chaikoff and Leachamn[18] found a high incidence of cataract in completely depancreatized dogs. The duration of the diabetes seemed to be a factor in the development of cataract. The animals which had been diabetic for the longest period of time showed the most marked lens changes.

Cataract is associated with a number of pathological conditions, both clinical and experimentally induced. However, the cause of disorder remains to be found.

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PERCEPTION OF MOVEMENT*

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I hope that, firstly, the younger readers of this paper who are still conversant with their physiologic optical definitions will excuse me for including in the early paragraphs three definitions of the retinal senses, and, secondly, that the older readers will excuse me for writing at length on a subject which seems to have little bearing on the practitioner's work.

Here are some elementary definitions of the retinal senses:

Light Sense is that cerebro-retinal property by means of which we are able to distinguish between various intensities of illumination. The minimum visible amount of light is known as the Threshold. The minimum amount of difference detectable, in ratio to the total intensity is known as Fechner's Fraction, and is normally around 1/100.

Form Sense is our ability to distinguish shape and detail. The maximum detail perceptible is known as visual acuity. At the Light Threshold visual acuity is extremely low, rapidly improving with increased illumination. Past a certain limit, increasing the illumination only makes the perception of detail more difficult, most probably due to the difficulty of retaining contrast (i.e., a greater difference than Fechner's Fraction).

Color Sense. Our sense of color is the ability we have of detecting the presence of, and differentiating between various wave lengths of light. This ability varies considerably in individuals, but few are able to perceive more than six changes throughout the spectrum.

I would now like to add to the list—

The Sense of Movement. This sense is in no way connected with convergence or accommodation but solely with the retina, as I hope to be able to make plain before I finish.

Let us take the case of a cinema screen where you may sit at any distance up to 200 feet away and view the movements thereon in comfort. If you care to try this experiment for yourself, you will find that by fixing one central spot of the screen, the image and all its movements may be easily followed.

*Submitted for publication July 28, 1937.

Again, on a Bjerrum screen, while fixing a central spot, the wandering target may be followed. Therefore, I think that we may consider the Sense of Movement a candidate with a strong claim for inclusion in the list of retinal senses.

After "movement," let us now consider "detail in movement" or, having mentioned static detail (paragraph 2), let us inquire into dynamic detail.

To start the wheels of thought revolving, let us go, once more, to the cinema. We are watching a news film. A hurdle race is in progress. Beautifully clearly we see the lifelike athlete gracefully taking the obstacles in his stride. Then, suddenly, in order to show us how the hurdler takes his jump, the picture stops and we see him suspended in mid-air above the hurdle. But is that all? No, we see a very blurred picture. There is a very woolly something over a very woolly something else. The picture then carries on as before, immediately regaining its clarity.

From the above and many other instances, I think we may deduce that movement influences the perception of detail.

If the movement of an object is extremely slow, it passes unnoticed; if extremely fast, the object becomes almost invisible. Small things slowly moving are more easily noticed than similar things stationary; but, on the other hand, small things quickly moving may be extremely difficult to see (as soldiers often found to their disgust in the unsanitary wartime trenches).

Compare the last paragraph with that on Light Sense, and note the similarity. In each case, as the light or speed increased, we pass from the ineffective to the effective and back to the ineffective.

In order to press the latter point further, let us imagine the hands of a watch. The movement of the hour hand cannot be seen; that of a minute hand on a normal sized watch is extremely difficult; the second hand is easy to follow; but if the latter is made to revolve very quickly by interfering with the mechanism, it becomes almost invisible.

In considering the speed as it concerns our eyes, we must consider it either at a given distance or angularly.

With various gadgets, mainly watches and clocks, I attempted to reach some definite numerical facts, and although they were obtained by extremely crude methods I give them to demonstrate the direction in which I worked. Measurements were taken at about ten inches, and with objects approximating a 2′ visual angle, and between points near the fixation target. The speeds are in "degrees per second" in a horizontal plane around an imaginary center between the eyes:

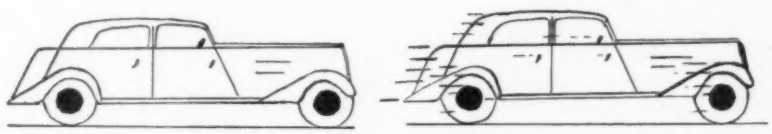
50 degrees per second—object invisible.
25 degrees per second—object barely visible.
.14 degrees per second—movement and object easily visible.
.042 degrees per second—movement almost imperceptible.
.0007 degrees per second—movement imperceptible.

The manner in which this movement influences Form Sense is far easier to demonstrate than to explain; and although the odds are decidedly in favor of its being a psychological rather than a physiological phenomenon, I fear to speculate, as yet, as to its true nature.

Persistence of Vision

In this age of constantly increasing speed, the most uninterested person cannot fail to realize the way in which Persistence of Vision makes itself noticeable. One has only to be passed by a fast car, broadside-on, at speed, and to notice how difficult is the perception of minor detail, to realize the fact.

In art, the aim is not so much to depict a scene or object as it is, so much as how it appears to be; and so we have always had the speed of an object suggested by drawing the leading edge of it more or less clearly, and the other by trailing lines. Thus, Fig. 1 (a) represents a car, but (b) a quickly moving one, and this by showing "persistence" behind it.



(a) Fig 1 (b)

It might be advisable here, briefly to show how Persistence of Vision, as seen in connection with moving objects, is considered to take place.

In following a moving object utmost use is made of the extra-ocular muscles on the fovea centralis. However, if the movement is sufficiently quick, the mechanism for that purpose fails to some extent.

Let us take for demonstration purposes a suitably sized black rotatable disc having on it a small white spot. If the speed of rotation is such that the eye is able to follow the path of the dot accurately and keep time with it, there is no reason why the spot should not appear clear, Fig. 2 (a). If, now, the speed is increased, we get the eye following in a series of jerks, the image spot no sooner having stimulated one retinal element than it is on the next, one element being stimulated a maximum bfore the previous one has recovered from the effect of its stimulation, and so on, causing the brain to receive a series of elongated light spots, Fig. 2 (b).

fig 2

However, when the speed of the disc has increased to such an extent that the eye can no longer follow the light-spot, a complete circle is seen, Fig. 2 (c).

Concerning the four Retinal Senses, I now wish to make a few remarks on the variations of these senses between the macular area and the periphery of the retina (or its space-projected field).

First let us consider Form Sense. At the macula we have the area of greatest discrimination, whilst the sensitivity to detail seems to fall off very rapidly as we pass therefrom outwards, the acuity being approximately equal to the reciprocal of the cube of the angular deviation. Below, I give figures in table form and also a diagram* showing the fall in acuity on passing from the fovea peripherally.

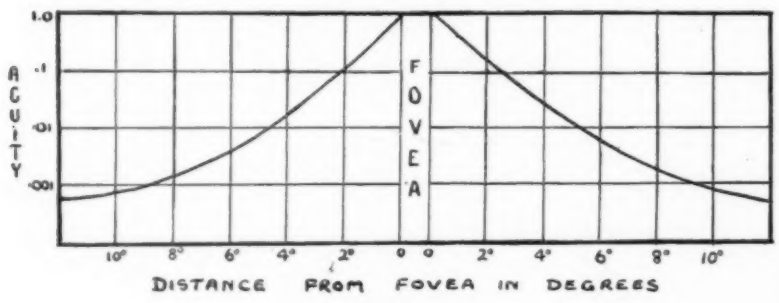


fig 3

*N. B.—These diagrams are neither intended as graphs nor drawn to scale, but are given as diagrammatic visual emphasis to the variations described.

If we take a table of the visual fields for colors and submit the statistics to similar treatment, we notice a very similar state of affairs.

Approximate limits of color fields (vertically through the fixation spot).

	Above	Below
White vanishes at	60°	70°
Blue vanishes at	40°	50°
Red vanishes at	30°	40°
Green vanishes at	25°	35°

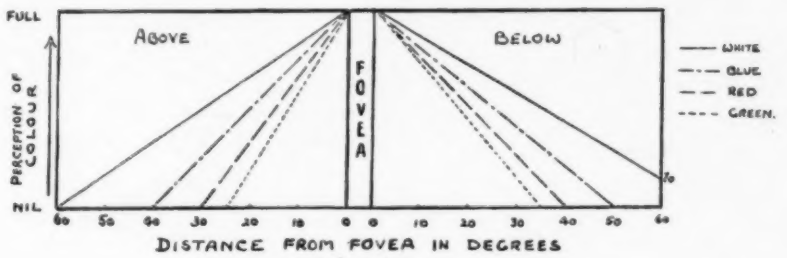


fig 4

In treating Light Sense, we are faced with the difficulty of having very little scientific data on which to work, but by simple experiment we are able to say with a fair amount of certainty that any diagrams or set of figures will not follow the form of the first two. At the fovea, for example, we do not get the apex of our "graph," but we do get two apices near to it on either side, with the sensibility gradually declining to either side. In fact, the visual threshold at the fovea is not a great deal better than at 90° thereto; and although we have less to guide us than before, we are fairly safe in considering the variations in the threshold value on the lines shown below.

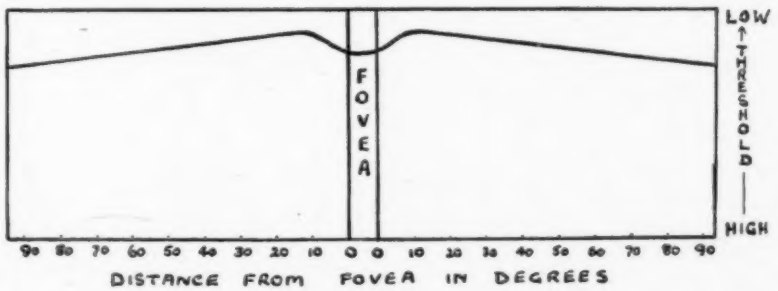


fig 5

Experiments on the Sense of Movement have convinced me of this: That the retina, or the brain via the retina, is almost equally sensitive to small movements of objects at the equator of the globe as in the macular region. How quick we are to appreciate movements at our side whilst looking ahead! Hence the phrase—"Saw it out of the corner of my eye."

Were I to try to represent my opinion of the variations of this ability, I should do so thus:

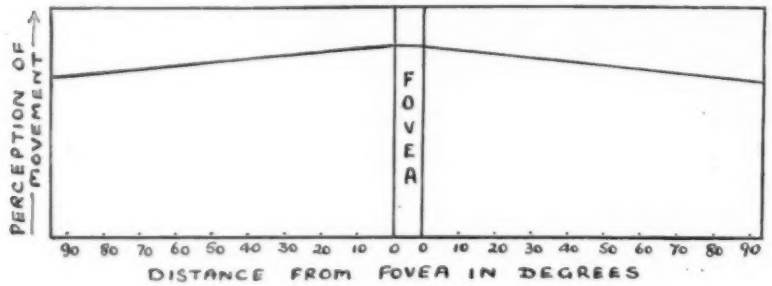


Fig 6

Perhaps the reader is wondering what I am getting at. Well, I can now get down to it. Let us compare these four diagrams. The thing that should strike one immediately is this: That, in form, Figs. 3 and 4 resemble each other and, again, so do Figs. 5 and 6.

If, now, we superimpose on each of our last four diagrams we will get the following results as shown in Fig. 7.

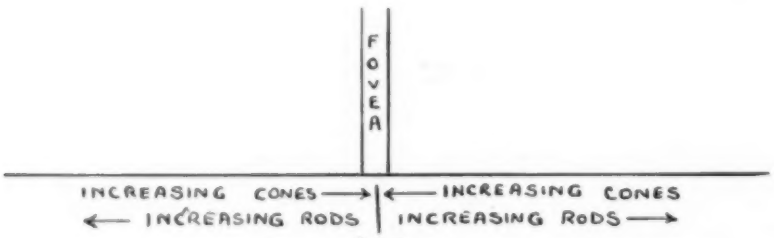


Fig 7

another important fact suggests itself, i.e., that the cones of the retina seem very essential to good form sense and good color sense (Figs. 1 and 2), and yet, in Figs. 3 and 4, we see that in spite of the absence or comparative absence of cones towards the periphery of the retina, good light sense and sense of movement are maintained.

Therefore, from the foregoing considerations I would suggest that, until proved otherwise, we may assume that whilst the conical elements of the retina are essential to good perception of detail and perception of color, the cylindrical elements are essential to good perception of light and perception of movement.

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AN EXAMINATION RECORD FORM FROM THE SYNTONIC VIEWPOINT*

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What is to follow is a lecture prepared to be delivered to Syntonic Optometrists to enable them to interpret data secured by using a method of case handling somewhat different from that formerly used by optometrists. No pretense is made that anything new will be presented, and it is admitted that much of what is to follow is common knowledge to optometrists, yet it is thought that the order of presentation and the correlation might be of some value. It is therefore hoped that you may find one or two points which may prove of value to you, should you make efforts to practically apply any of the diagnostic signs, or their interpretation, as they may be given.

In October of 1930 it became necessary to prepare a rather specific form for the collection of data and reporting to my office in connection with the then young technic in Optometry known as Syntonics. As a result of six years of use this method of recording data, with the possible interpretations, has proved its worth and value, particularly as it pertains to the technic mentioned.

Diagnosis is peculiar to the biological professions, medicine, dentistry and optometry, in that it requires not only the collection of objective symptoms, but those subjective symptoms that may be secured by intelligently questioning the patient. Having done these things the result of education, experience and judgment are brought to bear in the determination of the diagnosis, which is, of course, determining the nature of departures from the normal and applying a name thereto. Obviously, diagnosis cannot be made a slide-rule affair. *Stern* and *Kitchens* have both undertaken this task in behalf of medicine, but, even so, physicians still rely upon the time proved method of observing the symptoms and interpreting them without the use of mechanized systems of diagnosis. Neither dentistry nor optometry are likely to be any more successful in so ordering diagnosis as to make it automatic although undoubtedly attempts will be made to that end. Professions are not conducted in this manner, and therein lies the difference between a profession and a trade.

*An abridgment of the material presented before the American Academy of Optometry at Chicago, Ill., August 24, 1936.

In the professions no *two* problems are the same. In the trades there may be hundreds of problems the same day *all alike*. It, therefore, becomes the duty of any member of the biologic professions to know the possible and the probable indications of the signs and symptoms elicited. It shall be the purpose here to set up some common indications of the symptoms and findings, particularly those called for on the record sheet which is the basis of the present discussion.

We shall omit discussion of name and address and begin with the first statement which may give us a clue to the character of the departure from normal in any given way. On the record sheet the statement is "PATIENT COMPLAINS OF." All too often does the optometrist overlook the diagnostic possibilities inherent in the complaint. First of all the optometrist should keep constantly in mind that more often than not the *first thing* mentioned by the patient in his complaint is the condition giving him the most subjective trouble. This we call the "presenting symptom," and syntonically every effort is made to relieve this symptom at the *first* visit, particularly if it be one of an ache or a pain due to faulty ocular function. To list these is, of course, unnecessary here because all optometrists have been trained to check for headache, ocular pain, neck pain, dizziness, nausea, or other referred pains or symptoms of ocular origin.

In reference to pain the first consideration should be the *kind of pain*. These fall into four fundamental divisions:

1. *Dull aches*, usually indicate congestion or excessive muscular contraction. Sometimes this kind of an ache "thumps" with the heart beat. If the ache is due to muscular contraction in any of the intraorbitral structures it is of course very definitely an optometric problem.

2. *Periodic pains*. By this we mean pains that more or less occur at definite times of the day or following certain acts. Here we might list:

a. *Early morning head pains*. Quite often these are of sinus origin, but a more complete syndrome indicating sinus involvement would require that the pain should become *worse* after use of the eyes with possible referred pain in the neck, or nausea, and *erratic* phoria findings under the geometric optic test. Such a case should be referred to a rhinologist for a check-up and the correction of the existing pathosis before completion of the refractive handling. Of course, eyeball aches beginning in the late night and progressively becoming worse until the patient arises quite often indicates glaucoma and care should be exercised to rule this condition out of the case. At least two authorities state that early morning eyeball ache may be the result of refractive errors and that the ache is due to a congestion in the ocular muscles which does not completely disappear over night.

b. *When the eyes are open.* Here we are likely to find ordinary intolerance to light, or true photophobia as listed by *Martinet*, with keratitis, iritis of lens involvement as the basic causes. Quite often intolerance to light in the absence of the named pathoses is a mere neurotic exhibit and this should be kept in mind.

c. *When the eyes are closed.* Here we usually have some inflammatory condition which is usually not an optometric case.

d. There is another form of eyeball ache which is part of a vicious circle in that it is a result of digestive disturbances *caused* by some refractive error. Care should be exercised not to class this eyeball ache as the pathological glaucoma, which has often been done by optometrists, to the end that the ophthalmologist receiving the case reports to his colleagues how he secured another patient from a "sucker optometrist." If there is eyeball ache, make a field chart, and unless there is contraction of the fields, particularly the nasal fields, go easy in making a tentative diagnosis of glaucoma for the purpose of referring the patient.

3. *Sharp excrutiating pains* are usually due to inflammation, often with improper drainage. Such cases require immediate reference.

4. *Stabbing or shooting pains.* These are usually of nerve origin, and more often than not have as a background cause some refractive condition which, due to the operation of *Meltzer's* law, results in these referred stabbing pains. Correction of the refractive condition and proper syntonization usually will be all that is required.

While speaking of pain, it is well to discuss it from the standpoint of LOCATION.

1. *In the eyes.* Excess intra-ocular tension is the first possibility to be kept in mind; stretching of muscles or tissues beyond their normal; overuse of accommodation; overuse of convergence; esophoria; and sometimes ocular reflex digestive disturbances.

2. *In the head.* A very complete chart of location of head pains of ocular origin was at one time prepared and distributed by the writer, q.v.; also do not forget possibilities of esophoria, or of digestive disturbances of ocular origin. Persistent pain in the frontal portion of the head may be caused by pituitary gland involvement and sight should not be lost of this possibility.

3. *In the neck and the shoulders,* sometimes the *back of the head.* Here suspect exophoria or a high esophoria, the latter quite often of toxic origin.

4. *In the arms,* particularly upon motion. Here exophoria should be suspected and checked on.

Needless to say these pains that are listed as of ocular or ocular reflex origin should receive first consideration by the optometrist, looking to giving relief at the first visit if possible.

The next thing on the record is "PATIENT ATTRIBUTES HIS CONDITION TO." Strangely enough it becomes necessary to say that more often than not the patient is more nearly right as to the causative factor than some previous diagnosis or conclusion which he may give to you as having been reached by others. The complete history should always be taken so that your best judgment can be brought to bear upon the patient's statement of cause. Here let me inject a word of caution, *always* record in the history, and the subjective symptoms, the patient's statement in his own words on your case record. If he says "headache," write "headache" and not H. A.; if he says he "sees double," write "he sees double"—do not write diplopia. The patient is responsible for *what* he says to you or *fails* to say to you. You are responsible for the interpretation you put upon it. Therefore, *do not interpret what he says as a part of the record*. Put it down *as he says it* and the responsibility is his. A recent malpractice decision in a Supreme Court in the case of a physician brought this point strongly to the fore.

The next bit of data required is "AGE AT ONSET." Note this does not call for the duration of conditions, and the record should show the age at which the first subjective symptoms raised themselves to the patient's consciousness. The age at onset is important because:

1. It may go back to certain *developmental characteristics* which are determinable by observation of formation of certain teeth which is of no great importance here or to non-syntonists.
2. It aids in determining *progressive conditions*, or conditions that tend to go through varying stages of progress, usually from bad to worse as the patient gets older.
3. *Pre-pubertal beginning*. Here we have certain forms of clonic and tonic reactions which, if allowed to continue, may become permanent departures from the normal.
4. *Post climateric*, both male and female. Here, of course, we expect to find presbyopic findings, usually with low adduction.
5. *Between the ages of 15 and 45*. Here we will find the "run-of-mine" cases that come to our offices, the symptomotology of which it is not necessary to go into here except perhaps to mention early presbyopes or subnormal accommodation which should always be taken care of when found by methods available to the optometrist.
6. *After the age of 60*. Here we expect to find degenerative changes, opacities, and those other findings which indicate the beginning of the end. However, these cases require just as careful optometric and syntonic handling as those of other ages.

The next thing requested by the record is "CORNEA." You are familiar with the usual methods such as looking for scars, depth of the anterior chamber, corneal curvatures and the other routine methods. However, there is one bit of examination which I think should always be made, particularly in cases of low naked vision or visual acuity and that is the observation of the cornea with a Beebe loupe while the cornea

is being *obliquely* illuminated by a rather strong source of light. The purpose of this examination is to determine the degree of "polish" or transparency of the cornea. It is surprising how many corneas are found in patients with lowered acuity in which the suggested kind of observation will result in the finding of lessened transparency.

Corneal scars, of course, impair vision if they are near the axial line of the pupillary area. Incidentally, the scars may often be made more transparent, and in some cases fully transparent, by the use of properly selected light frequencies resulting in a decided increase of acuity in some cases. Any gain in acuity in corneal scar cases is certainly most gratefully received by the patient and the effort should always be made.

The record next calls for the "PUPIL." A small pupil physiologically indicates parasympathetic dominancy. The pulse rate is an aid here in determining this factor. However, small pupils may be caused by the administration of cocaine, the opium derivations and hemorrhage into the pons. The latter, however, would not likely be in your ophthalmic chair, however, the two preceding might be. The large pupil indicates a sympathetic overactivity. Here again, the pulse rate gives a good check. Do not forget, however, that large pupils are always found in Grave's disease and after the use of atropine, belledonna, given internally, and alcohol. Sight must not be lost of the fact that belledonna is a very commonly used drug by physicians, and I would warn you not to classify any patient as a premature presbyope, as having subnormal accommodation, or as a bifocal case, if the patient is under 40 years of age, without first inquiring of the patient if he has within the just past three hours, taken any medicine of any kind, proprietory or upon prescription. If upon prescription make an effort to learn from his physician if belledonna is one of the ingredients. This simple check-up may save *you* the cost of a pair of bifocals wrongly prescribed.

Another pupillary finding is what we call in Syntonics the "ALPHA OMEGA PUPIL." This type of a pupil indicates an endocrine involvement, but when found one will always find low reserves and low recoveries by the usual geometric means. This is not the time nor the place to go further under this particular diagnostic sign since many of you would have no adequate means of correcting the ocular manifestations. *Unequal pupil* size may be caused by some involvement of the upper spine, in which some of the manipulative practitioners may prove of service. On the other hand, unequal pupils may indicate some very serious diseased conditions, one of such being aneurism of the aorta. It might be well to always refer any patient having unequal pupils to some other practitioner for diagnosis before rendering further optometric service.

Irregular pupils. Here, of course, no optometrist would be guilty of overlooking an iridectomy. On the other hand, irregular pupils may be caused by a synechia which may have resulted from an old iritis, iridocyclitis or possibly a severe keratitis. If the active stages of the pathosis

have passed, the optometrist will, of course, do the best he can refractively, or the syntonist might well use some one or more of the indicated frequencies in an effort to get better vision.

Gray pupils. These are not always lenticular opacities, but may be the result of old age, nor should failure be made to rule out translucency in the cornea just in front of the pupil. In glaucoma the pupils often take on a gray appearance.

We come now to the word "SCLERA" on the record sheet. While in school we were taught that the sclera is a tough *white* fibrous outer coating of the eye. But it is not always white. It may have a yellowish cast, be definitely yellow, or have a greenish-yellow cast, or it may have a bluish-white sheen like mother-of-pearl. Each of these color changes has a very definite indication, but these indications are of no great significance in geometric optometry.

The "AQUÈOUS" is the next thing called for. Here at times we find a cloudy aqueous, or hypopyon, both of which may be definite pathoses and should be referred immediately. Occasionally moving particles may be seen in the aqueous. Under oblique illumination, after having the patient close the eyes and applying quick pressure at the region of the limbus and then suddenly opening the eyes, will quite often show these moving particles as flakes in the aqueous. The illumination must be almost parallel to the plane of the limbus. Such moving particles, if observed, usually do not indicate a pathological process although they are probably the result of some prior pathologic condition.

On the record sheet we find that the "LENS" is the next consideration. Despite all instructions it seems that many optometrists still use the ophthalmoscope for the purpose of locating lenticular opacities. They can best be *located* by the retinoscope and then be examined closely under about a 16.00 with the ophthalmoscope. Attention should be directed to the significance of the shadow cast by the edge of the pupil on the lens by oblique illumination. A perfectly transparent lens and capsule should show no shadow, while a decrease of transparency shows an increasingly darker shadow as the opacity becomes more dense with a consequent lessening of transparency. A further examination of the lens should be made by extremely oblique illumination and the surface of the anterior capsule should be observed through a Beebe loupe for roughness. Optometrically speaking, a roughened anterior capsule causes a poor prognosis for improvement in vision.

If opacities are seen it is well to show them to the patient. I have found the Mediascope of *Cassity* to be most helpful. This device gives a specially projected circle of light apparently about 14 inches in diameter. The normal eye merely sees a circularly illuminated area, whereas opacities in the media as far back as 3 millimeters behind the posterior capsule, are observed by the patient as dark spots in the illuminated field. It is my custom to have the patient draw on a card what he thus sees and to file this card with the record for future reference.

While observing the lens, the "IRIS" should be checked for any anterior convexity which might indicate swelling of the lens. An anterior convexity of the iris tends to lessen drainage and may result in secondary glaucoma. Such a condition, obviously requires very careful and close watching by the optometrist in order to prevent any permanent damage to the eye by immediate reference if untoward symptoms occur, particularly if the fields show any contraction upon successive field chartings.

The record next calls for findings in the "VITREOUS." Here cloudiness is the most common finding and usually is the end result of hemorrhage or some other pathosis. If the ophthalmologist says the pathosis is quiescent, efforts might be made by Syntonic Optometry to see if vision can be improved.

Of course, the presence of floating bodies in the vitreous should be recorded, although I have always had some personal doubt as to motion by such bodies due to the relatively high viscosity of the vitreous. I am quite often asked about persistent hyaloid membrane. We have been unable to improve vision syntonically in such cases.

The "FUNDUS" is the next thing on the record. Here in addition to the well known things to be observed it is well to remind you that any great differential between the darkness of the veins and arteries has a definite syntonic significance and is usually handled by non-local nascentization in addition to the proper frequency. *Pallor* of the entire fundus may mean that your patient is a sufferer with migraine. In migraine cases always check very carefully for exophoria, and if found it should be compensated for by prisms, rather than to make efforts to overcome it by building adduction. In parts of the country where maleria is prevalent pallor may indicate quinine poisoning.

The next thing called for on the record is the "CHOROID." Normally the choroid, of course, cannot be seen, but if it is observable it should be checked by an ophthalmologist to determine if the pathosis is in an active or static condition. If static, vision quite often can be improved syntonically.

"TEETH" are the next thing called for on the record. The shape of the front six teeth in the upper jaw, with their relative sizes, should always be drawn on the record sheet. These teeth give us a clue to the developmental status of the individual and quite often point to the type of ocular functional involvement which may be present. Obviously, artificial dentures are of no value here.

The next consideration is given to the "COLOR FIELD CHARTS." The indications here are well known although it might be well to mention a few which bear emphasis. Tobacco usually shows a central scotoma in addition to contraction of the red and green fields. Tabes usually shows a concentric contraction of all fields. Nasal contraction of the visual field may indicate an early glaucoma and if the contraction continues to increase the case should be referred. Please do not confuse "field of vision" with a retinal area involved. These are opposites.

Speaking of scotoma reminds me that careful search should be made for evidence of a central scotoma in the presence of nystagmus. If such a scotoma exists the nystagmus may be materially improved by the use of a proper syntonic frequency. Strangely enough, there is another very common condition which sometimes causes nystagmus as a result of reflex irritation. This condition is a hardening of the wax in the external auditory canal. I have had four cases in which removal of the wax has cleared up the nystagmus.

I am somewhat surprised at the non-critical use of N.V. and V.A. These are not synonomous. Incidentally, a little trick that I have found helpful is to suspect exophoria and/or low adduction when vision O.U. is *less* than it is with each eye singly. The mechanism here should be obvious, but it has apparently been overlooked in some examination routines.

After taking the vision with the old lenses and without lenses, vision should be taken with the "PINHOLE." Here sometimes we find, particularly in opacity cases, that the pinhole tends to improve vision in cortical type opacities and in most cases impairs vision in nuclear, polar and capsular opacities. Clinically we find that about sixty per cent of the opacities cases that show improved vision under the pinhole show a more or less permanent improvement of vision under the syntonic technic, while only about thirty per cent of those in whom the pinhole impairs vision show any gain. Of course, you are all familiar with the function of the pinhole in geometric optics.

Strangely enough, the record sheets call for the "INTER-PUPILLARY DISTANCE." It is surprising how many times data are submitted for interpretation without this measurement and I feel frank to say to you that it is utterly impossible for me properly to determine the ocular demands in any given case, particularly as they pertain to the relationship of convergence and accommodation, without this measurement. In other words, quantitative ductions and reserve fusion findings are valueless from an interpretative standpoint without the interpupillary distance *and the phoria finding*. Do not forget to add the exophoria, or to subtract the esophoria, to get proper quantitative figures with which to deal.

Here it might be well to mention that the peripheral areas of the retina also have a distribution in the brain in the region of the macular distribution. Therefore, the problem is, how well does the non-dominant eye "catch up" with the dominant eye at the point fixated? In other words, how quickly does the non-dominant eye fixate the point already being fixated by the dominant eye? I sometimes believe that our so-called duction tests do not give data of value, but that tests should be devised to determine an answer to the question above. The eyes are moving constantly, in planes, and as I have said, it is *not* a problem of how far the non-dominant eye can be deviated from the fixating eye as we do in the duction tests, but how quickly and effectively does the non-dominant eye fixate the spot fixated by the dominant eye. I would

recommend to this academy that some competent Fellow might well be assigned the problem of developing a test along the lines here indicated, because after all a pair of eyes act much like a team of horses, and if the "off" eye does not effectively follow the "lead" eye we would have the same problem, or a worse one, than if the "off" horse of a team went one way and the "lead" horse, obeying the reins, went another. To have effective comfortable vision the "off" eye must instantly follow the "lead" eye in a practically effortless and strainless unconscious manner. Our present duction tests determine how far they can be deviated, an entirely different thing.

This brings us to the next thing requested on the record, the "DUCTIONS." Conditioned responses may be impressed upon striped muscle, but always depends upon prior conscious action and upon the kind and type of stimulus. Unfortunately, conditioned responses tend to revert to the originally unconditioned status unless the conditioning mechanism is more or less constantly being brought into action. Snappy recovery after break tests is apparently a result of proper blood chemistry, due to adequate functioning of certain of the endocrine glands. Erratic and changeable duction findings, or erratic phoria findings, should call for an immediate check-up of blood pressure, which may indicate that the patient should be referred to an internist immediately.

We now come to "AMPLITUDE OF ACCOMMODATION." There are many methods for making this test which obviously call for varying interpretations. Sight must not be lost, however, regardless of the technic used, of the fact that the amplitude of accommodation is in reality a test of physiologic age of the patient, which may not necessarily agree with his chronologic age. You might say that your patient is physiologically as old as his amplitude of accommodation indicates him to be, a not pleasant thought for those requiring lenticular assistance for close work whose age is less than about 45. Incidentally, the physiologic age is really a matter of glandular secretion. It was one time held that man was as old as his arteries. Now we say he is as old as his glands. The ocular manifestation of glandular under-function is largely in the plain muscles, in the present instance the ciliary. The ability of plain muscle to hold contraction is not a matter of nerve stimulus. The stimulus may determine *when* it contracts, but its ability to hold contraction is a matter of chemistry. For this reason it is rather difficult to "train" plain muscle, also because the action of plain muscle is below the conscious level it is next to impossible to establish conditioned responses. Its action, therefore, depends upon the inherent physiologic mechanism.

The record next calls for "BIOTYPES." It should not be necessary to state that the biotype of the patient is to be determined by bone formation and not by accumulation of fat. There seems to be much confusion on this point. The asthenic type shows a tendency to quick reactions and sometimes over-reactions to stimuli, with lack of power of sustained action; while the pyknic more often has slow reactions but a

greater ability of sustained power, with a tendency to tonic contractions. The study of biotypes and their ocular reactions is one which is entirely too long for this paper. Suffice it to say here that optometrists should *not* expect the same ocular reactions to the several tests in the different biotypes. In other words, the result of any ocular test should be interpreted only after determining the biotype, to do otherwise is to court false conclusions.

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ASTIGMATISM*

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In treating this subject of astigmatism there is very little of the material offered which is new to the student of this anamoly, that is, to those who compose the membership of the American Academy of Optometry.

However, in setting forth the meager results of my efforts in presenting, in generalities, the cardinal principles of this important subject I am inspired by a realization of the value of attempting to master the "old" while continuing to seek the "new."

Because astigmatism is a subject of basic importance the studious and rational conception of which influences with the majority of our cases, the entire gamut of our ocular diagnosis, we cannot review too frequently or too seriously the tenets governing its true understanding. One of the most incorrigible problems with which we have to contend is the cylinder element in refraction since it offers greater perplexities throughout the entire field of procedure.

An erratic evaluation of astigmatism cannot only disorganize the entire diagnostic chain of findings but an uncorrected compensated astigmatic error results in two-thirds more stress than a spherical anamoly of equal amount.

Since the cornea and the crystaline lens contribute most of the astigmatism of the dioptric elements of the eye a substantial part of the discussion will revolve around these centers.

Influence of Heterophoria on Corneal Curves

There are very few human cornea that are symmetrical or constant in relative curvature due in part to the paraboloid curvature of the cornea. The normal cornea is not a segment of a sphere. While the average normal cornea is to some slight extent astigmatic the average normal eye is non-astigmatic.

Some or all of this normally expected .25D to .50D corneal astigmatism (due in part to slightly greater curvature vertically than

*An abridgment of the material presented before the American Academy of Optometry at Rochester, New York, June 25, 1937.

horizontally) is neutralized as the result of the angle of approximately five degrees formed by the visual and optic axes. Some investigators claim that this angle varies from five to ten degrees under certain accommodative influences.

Because the cornea contributes about two-thirds of the total dioptric power of the entire globe and because it is basically the greatest factor in astigmia, we should analyze the influences which are exerted upon the cornea resulting in corneal astigmatism.

There is such a condition as an uncompensated unenvolved structural corneal astigmia and conversely there is known to exist a corneal asymmetry not anatomical but induced by innervational causes.

Let us consider some of the innervational factors contributing to the variable type of corneal astigmatism.

In conformity with the rule governing cases of oblique astigmia (other than the type with parallel axes) the images are distorted toward the meridian of greatest curvature and similar image points fall on dissimilar retinal points. To avoid the resultant diplopia the obliques effect compensatory eye movements to correct the disparity. Savage speaks of this as "compensating cyclotropia" and further states that if such rotations are impracticable amblyopia exanopsia frequently results.

While the resistance of the globe against pressure varies somewhat with the thickness and tensile strength of the sclera and intra-ocular pressure, we are aware that the act of binocular vision entails an amount of pulling, drawing and pressure exerted against the plastic eyeballs by the extra-ocular muscles. We have a hint of the extent to which the extrinsics can assist in attempting to adjust the focus of the eye in the apparent accommodation in an aphakic eye. Although some of the apparent accommodation in aphakia may be due to a high chromatic aberration.

This extra-ocular pressure is not an adverse influence in the presence down the disparity between the ophthalmometric and subjective or if there is an imbalance within the scope of compensation the resultant effort toward the end of the directional and visual poise can exert an extrinsic muscle pressure against the globe which adversely influences corneal curves. This type of pseudo corneal asymmetry is of the unstable variable type.

Stevens asserts that astigmatism is caused by loss of sphericity and in many cases this loss of sphericity is due to the traction exerted by the muscles surrounding the eyes.

If such pulling and pressure exerted by the extrinsics due to ocular adjustments in compensating a heterophoria causes unequal corneal curves there is a possibility that lenticular assistance may offset totally or in part this corneal astigmia so that there will be a significant discrepancy between the ophthalmometric reading and the skiascopic total.

It is not alone in isolated cases of heterophoria associated with astigmatism but in a substantial per cent of such cases that the corneal of a structural and innervational balance of the musculature. However, measurements are variable as measured periodically during the course of orthoptic procedure. The writer has found that in a significant per cent of cases where efficient intrinsic and extrinsic performance is restored through training and correction of ametropia that both corneal and lenticular astigmia is in part or totally reduced. It is not uncommon as you well know to encounter a subjective or skiascopic visual demand for a cylinder axis 90 degrees apart from ophthalmometer findings. In many such cases where orthoptic training is indicated if spheres are prescribed during a period of training that an eventual result does obtain frequently enough to justify such a procedure of an approach toward breaking skiascopic findings. Sometimes this reversed axis is due to a chronic accommodative cramp. With the fullest acceptable spherical correction along with a restoration of muscular innervational balance through orthoptics when indicated the axis of cylinder will eventually be accepted in its true position or permanent position for the individual case.

Such occurrences would be more popularly noted if operators would as a matter of routine make periodic ophthalmometric tests during the course of orthoptic training and diagnostically compare its variable findings with the original ophthalmometric reading and with the extra ophthalmometric tests. It is too frequently the case as a matter of time economy to make but one reading of corneal curves. This lessens the value of the ophthalmometer as a diagnostic vehicle.

The writer has grown suspicious of any stability and permanency of cylinder value when there exists a substantially uncorrected heterophoria especially when associated with a latent hypermetropia.

When a compensated ametropia remains uncorrected or but partially corrected there very frequently results an innervational astigmia which is variable in amount. It sometimes occurs that as the full ametropic correction is approached the amount of needed cylinder value lessens in amount and becomes more stable and in some class of cases the pseudo astigmia disappears when the full ametropic error is corrected. As a rule myopes more nearly accept the full ophthalmometric findings than do the hyperopes.

In the light of these experiences which we all encounter it follows that in order to do justice to this innervational type of astigmatism it is necessary to correct any existing heterophoria and ametropia before attempting to arrive at a correct and final cylinder value. The result is a defeat if we arbitrarily follow the dictates of the ophthalmometer with this evolved type of astigmia without first removing the provocative conditions.

Ophthalmometry

While the majority of writers endorse the ophthalmometer as an asset it seems to remain a controversial issue among a few. If the operator expects to prescribe that cylinder component of the ametropic correction unalterably as found with the ophthalmometer in 100 per cent of his cases, he is doomed to disappointment. There is no scientific reason for accepting as final the corneal astigmia which is but one component part, if too glaringly contradicted by the subjective and skiascopic findings which is the sum of all the astigmatic parts. Since the cornea contributes two-thirds of the dioptric power of the eye and is the source of the greatest single factor in astigmatism, a knowledge of its curves as provided by the ophthalmometer is of indispensable diagnostic value to the skillful operator.

Let us next consider some of the reasons why this corneal astigmia as shown by the ophthalmometer cannot always be accepted as final and conclusive:

1. Sectional accommodation and a possibility of some posterior corneal curvature influence.
2. Ophthalmometry is a monocular test.
3. Discrepancy in size and shape of ocular images.
4. Physiological astigmatism.
5. Disparity resulting from correcting lens effectively placed approximately 15 m/m from cornea.
6. Allowance for effect of the sphero-cylinder combination.
7. Oblique cylinder findings differ in strength and position of axis.
8. Axis varies occasionally as result of torsions and declinations.
9. Total spherical strength of lens prescription.
10. Difference between the index of the cornea and the assumed index of the cornea used as a basis for the ophthalmometer cylinder.

We might be led to assume from the foregoing that the ophthalmometer is of little practical value to the operator but if we weigh all of the important evidence the unbiased verdict will be that this instrument is invaluable to the scientific practice of optometry.

The ophthalmometer not only gives as a clue as to the kind of ametropia to be expected but subsequent readings as I have previously pointed out reveals whether or not the eyes are changing. Frequent or drastic changes in corneal asymmetry are sometimes associated with ocular diseases, or imbalances of the eyes and the nervous system. This instrument discloses any existing corneal irregular astigmia reveals abrasions and other corneal abnormalities. Despite the variables enumerated above we must admit that in the majority of cases the corneal asymmetry is the greatest factor in the total astigmia. While we cannot expect the

ophthalmometer to give us the exact cylindrical prescription its findings can be accepted as a basis for calculation subject to alteration with auxiliary measures. In a substantial per cent of cases we can expect to closely approximate the ophthalmometric disclosure of regular astigmatism making due allowances for physiologic astigmia.

The various rules with which you are familiar used for allowances in computing ophthalmometer readings are assistive but far from infallible. Since these rules are so generally understood space will not be devoted in this paper to a discussion of their application. The principal value of these rules is to determine as nearly as possible how much of the total astigmia is corneal and how much is lenticular.

Dr. Neumueller disproves Javal rule and states,

> "that the disparity between the correcting cylinder and the corneal astigmia is due to two factors, namely, the distance to cornea from correcting lense and the prevailing ametropia. The one of greater magnitude will exert the greater influence."

Where the total astigmia is at such decided variance with the corneal astigmia as to indicate other influencing factors besides the accommodative compensation, it is well to look to other possible causes. There might be a tilted, partly detached area of retina in the region of the macula causing so-called retinal astigmia. Such toroidal surfaces rather than causing astigmia merely produce effects simulating irregular astigmatism not disclosed by the ophthalmometer. There may exist other conditions contributing to this disparity between the total irregular astigmia and the corneal manifestation. There may be a distortion of the lens or its capsule, a luxation of the lens; an unequal index of refraction by different areas; lens changes due to development of cataract.

It might be well to mention at this point a general tendency but with wide exceptions, of a greater or lesser degree of shifting of axis of cylinder as age progresses. The shift is from minus horizontal axis in youth toward vertical axis as the degenerative years are approached. With some cases there is a gradual shift of axis a few degrees at a time over the period of years while with others there is in a shorter period of time a more or less abrupt change from approximately minus 180 degrees to approximately 90 degrees axis. In all cases both eyes do not manifest an equal or simultaneous shift of axis for frequently one eye changes before the other.

With some subnormal vision cases where the corneal irregular astigmatism is so extreme as to warrant such drastic measures, contact lenses which act as caps holding fluid, neutralize the irregular astigmia.

Lenticular Astigmatism

There is a growing opinion that the crystaline lens or its position is a factor in contributing or compensating an existing astigmatism.

Skiascopy and subjective techniques are the only methods which

will reveal in its entirety the total astigmia. Assuming accuracy on the part of the operator the comparative difference between the cylindrical value as disclosed by the skiascope for static and dynamic gives a hint as to the amount of lenticular accommodation at near point compared with far point, allowance being made for influence on accommodation by fusional efforts. Since the work of Dobrowolski in 1885 there has been some division of opinion regarding the existence of dynamic lenticular astigmia but as the result of improvement of skiascopic technique modern investigators are leaning more and more to the view that dynamic retinoscopy gives evidence of changes in the refractive astigmatic condition with different degrees of accommodation.

As to the possibility of unequal accommodation the postulates that unequal stimulation of the ciliary results in irregular deformity of the lens is supported by evidences revealed by cyclopegic tests and the disparity in cylinder values with subjective comparisons between fogging and non-fogging techniques.

Sectional accommodation denotes that condition in which the cylindrical effectivity of the eye is increased during the act of accommodation.

There are two types of sectional accommodation, one in which there is an excessive activity of the meridianal fibers compared with sphincter activity and the reverse condition where the excessive activity is with the sphincters."

"Innervational type of sectional accommodation may be symmetric affecting two opposite sectors of the lens, or asymmetric affecting only one sector of the lens."

We all have experience with astigmatic envolved cases which require increasingly stronger cylinder corrections with each subsequent refraction until with many such cases an eventual approach to the full acceptance of ophthalmometric finding is experienced. It is also very commonly observed among older people that stronger cylinders are accepted as accommodation gives way to the influence of age.

Of the two major refractive media of the eye the cornea is the greater and the more stable while conversely the lens is the lesser of the two major refractive media and the less stable and will yield more easily to compensatory adjustments in the interest of clear vision.

The writer has met with considerable measure of success in cases where lenticular astigmatism seemed in evidence to prescribe tentatively among the more tolerant patients a cylinder from 25 to 75 D. in excess of the accepted finding, as influenced by the ophthalmometer around which is built the best possible sphere.

However, few cases will tolerate full cylindrical correction of high degree wherein no correction has been previously worn. A modified cylinder within the limits of tolerance should first be supplied with the view of approaching the full latent astigmatism in time to come.

Sometimes an accommodative stress resulting from the accommodation trying to assist convergence overcome high exophoria will induce a high astigmatic error with oblique axis as revealed by skiascope and subjective but which are contra-indicated by ophthalmometer. Usually in such cases binocular vision is of low grade with some suppression, low grade fusion and perspective and low positive amplitude. Such an oblique axis is pseudo and more gratifying results in such cases will accrue from following the dictates of the ophthalmometer.

Investigators claim that uneven retinal surface in the region of the macula results in a sectional accommodative effort to produce a clear cut image and that discrepancies in image size, induces unequal accommodation. It is further set forth that a correction of this disparity of image shapes and sizes will overcome the accommodative astigmia.

We must not lose sight of the fact that an uncorrected astigmatism of unequal amount can likewise produce a disparity in size and shape and intensity of ocular images.

Sectional accommodation can induce an irregular pupil since each sector of the ciliary and iris is innervated by their controlling ciliary nerve.

One of the chief causes of spasm of the accommodation is uncorrected compensated astigmatism. One method of correcting astigmia is to give, along with a full spherical correction, orthoptics while the patient is wearing the full ophthalmometric findings, while at other times the patient wears a modified and tolerable prescription which gives reasonably clear vision.

Sectional accommodation impairs the normal accommodative convergence relationship. To this extent it indirectly interferes with the refinements of binocular vision. It is not difficult to clinically demonstrate in such cases, a marked improvement in stereopsis and quality of fusion following a correction of sectional accommodation. In extreme cases, sectional accommodation results in suspenopsia and even in amblyopia.

In enumerating as treated in this paper, the possible adverse effects of uncorrected astigmatism there are the following: Heterophoria; anisometropia; suspenopsia; amblyopia; ex-anopsia; disparity in retinal image size, shape and intensity; spasm of accommodation; interference with accommodative convergence relationship; creating of approximately two-thirds more asthemopia than a spherical ametropia of equal amount and disorganization of the entire diagnostic chain.

We are thus again reminded why some efforts at both refractive diagnosis and orthoptics result in disappointment and why one of the important and basic requisites in our diagnosis and corrections revolves around an intelligent administering to this elusive anamoly—astigmatism.

The methods popularly employed to arrive at a cylinder correction

are: ophthalmometry; skiascopy; trial lenses; stenopaic slit; astigmatic charts and cross cylinder check tests, the latter of which is not as generally used as its importance deserves. It will not be necessary to discuss before this advanced group the modus operandi of these specific techniques.

In conclusion, the following summary covers the cardinal elements treated in this paper:

1. Value of ophthalmometer as a diagnostic instrument.
2. Influence of heterophoria on corneal curves.
3. Influence of ametropia as a factor in pseudo astigmia.
4. Importance of restoration of efficient intrinsic muscular performance and extrinsic directional poise through correction of ametropia and orthoptic training as a means of combating an innervational astigmia.
5. Possibility of lenticular astigmia as a compensator of corneal asymmetry and as a cause of pseudo astigmatism and accommodative astigmia varies with distance.
6. Accommodative effort to assist convergence overcome high exophoria commonly induces high astigmatic error with oblique axis in which case the dictates of ophthalmometer should be followed while orthoptics is prescribed.
7. Total astigmia is sometimes at such decided variance with corneal astigmatism as to suggest other influencing factors such as tilted, partly detached retinal area near macula; distortion of lens or its capsule or a luxation of lens; unequal index of refraction in different areas and lens changes coincident with approach of cataract.
8. Numerous adverse effects of uncorrected astigmia on diagnosis of the visual mechanism.

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A RECENT ADVANCE IN SUBJECTIVE EYE TESTING*

In viewing the technique of an ocular examination as a complete or finished thing, one is at once struck with the obvious, yet at times overlooked fact, that a considerable portion of the final end result is due to the findings obtained while making the subjective part of the examination routine. To be sure, the newer objective tests which have taken such a prominent place in the optometrists' refracting room procedure during the past twenty years, have received, and for that matter, still do receive most of the attention wherever optometrists gather. These objective tests, because they almost invariably call for a considerable amount of skill on the part of the examiner, do challenge the interest of the optometrist and therefore when once mastered, seem to occupy a place of importance, sometimes indeed far out of proportion to the real worth of the test or technique itself. For this reason, it is sometimes well to pause and take stock of one's abilities, and see if every phase of our work is getting the attention it should and also if we as modern eye specialists are keeping abreast of all new developments in refractive

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science, those having to do with the subjective tests as well as the advances made in the objective branch of our refractive work.

With this in mind I have prepared the following review of one of the newer advances made in subjective eye testing. This will be given as it was presented to the profession by J. Robinson Cohen, of New York City. His technique is simply refinement of one of the older subjective techniques suggested years ago by Lockwood and others, back in the days when the subjective finding was the sole basis for the prescription. As a refinement, however, this suggestion will be found to be of considerable value as it does tend to make this portion of our work more accurate and at the same time tend also to bring all portions of the examination into closer relationship. In presenting this suggestion regarding the improvement of our subjective techniques, I do so with no thought of criticizing or belittling the objective portions of our examination routines. These are just as important as they ever were, and no attempt is made here to infer that any of these objective tests should be omitted. However, some of the findings of these objective tests might be better understood by adapting the suggestions which have been made to improve the subjective portion of one's present examination routine. It is with this in mind that this short review is presented.

The purposes of the subjective refraction being understood and the various factors affecting the accuracy of the findings also being known it is the intent of this paper to review the Cohen technique, which offers several improvements of the subjective test. As is known, speed, accuracy and simplicity, as well as control of accommodation, are the essential requirements for a subjective test. In the interest of these requirements, the test has been divided into three separate parts as follows:

A. Measurement of the astigmatic error.

B. Measurement of the manifest spherical error and balancing of the monocular findings.

C. Investigation of the accommodative activity.

It might be mentioned here that special charts have been designed for use in Parts A and B of the test, and a conventional letter chart is used in Part C. All three charts have been combined on one slide which is designed to be used with a machine of the type of the American Optical Company's Project-O-Chart.

A. Measurement of the Astigmatic Error.

According to Cohen the purpose of the subjective test is to reduce or eliminate the reginal blur circles by accurate focusing. Therefore the first step in the subjective test should be the reduction of all retinal blur SHAPES to CIRCLES. It has been demonstrated that in the case of a sphero-cylindrical lens (corresponding to a compound astigmatic error) the shape of the blur circle varied from a thin line to an ellipse, depending upon the focal lengths of the system and the position of the screen.

The reduction of the blur ellipses to blur circles requires the correction of the astigmatic error—the reduction of the sphero-cylindrical system to the spherical system. This is the purpose of Part A of the suggested technique. For many years, the commonly used test object for this operation was the astigmatic clock dial or fan dial.

This chart although still used by some refractionists, has been discarded by most investigators because of the uncertain results obtained. The fact that, in some cases, accurate findings are easily obtained with the astigmatic dial, while, in many other cases, the findings are totally unreliable, is an excellent demonstration of the effect of the psychological factors of vision upon the findings. From a purely mathematical viewpoint, little or no criticism can be leveled at the astigmatic dial, fan dial, and a host of other geometrical designs for astigmatic charts. However, the actual image of the chart, as produced upon the patient's retina, is of secondary importance to the apparent image produced in the patient's mind, because of the very meaning of "subjective." The patient tends to rationalize the object viewed according to remembered patterns. If the patient believes that the lines should be equally black, as on a clock face, for example, there is definite mental tendency to equalize the difference in blackness, particularly if the transition of shade is gradual and not too marked.

Cohen points out that the accuracy of the findings depends upon the patient's interest and ability to overcome the tendency mentioned above, rather than upon the actual type of blurred image produced upon the patient's retina. Furthermore, visual memory, attention, et cetera, are not abstract and theoretical considerations but real and practical factors nullifying the value of techniques designed without their consideration. The objections outlined above also apply to charts requiring equalization of limbs of an arrow. Recent trend in astigmatic chart design has been toward charts having lines at right angles only.

The chart designed by Cohen to be used in part one of the suggested technique consists of two broken lines arranged at right angles to form a cross and displayed on a monochromatic background. They can be rotated to any desired axis. The effect of the design is to produce definite and easily recognized blur images for different astigmatic errors, so that the axis and amounts of astigmia, if present, can be rapidly and accurately determined. These blur images are explained in the following paragraphs. It must always be remembered that the blur image has no sharply defined outline but fades very gradually from a deep black, or gray through the shades of gray into white.

If, according to Cohen, an opaque black square arranged on a luminous white background is placed in front of a convex spherical lens, and screen placed at the conjugate focal distance on the other side of the lens, an image will be formed on the screen. If the appearance of the square and background were clear and clean cut the image will have the

same appearance, but will probably differ in size. If this screen is now moved away from the lens, the image will increase in size, but the intensity of the image will be reduced. The image will be blackest at the center and shade off through decreasing intensities of gray into the white of the background. This loss of intensity or blackness is due to the blur circles formed by the infinite number of minute light sources constituting the background.

If instead of moving the screen away from the lens, a convex cylindrical lens is added to the spherical lens, the effect will be to bring the focus forward in the meridian at right angles to the axis of the cylindrical lens and to produce blur circles in that meridian. Attention is called to the special condition in which two opaque black squares of equal size are separated by a distance equal to the width of squares, and the design is viewed from such a distance that the square subtends an angle slightly greater than the angle of minimum visibility. It is pointed out by Cohen that, in this special case the blur circle from the first square fades from gray into white at the same rate as the blur circles from the second square. As a result, that area common to both blur circles will have a reinforcement of each blur circle by the other, and the effect produced will be that of a continuous line of varying blackness.

Now if a series of squares forming a cross are substituted for the single square, the corresponding images will be seen as either horizontal lines or vertical lines rather than squares. It is important to note that in hyperopic cases or myopic cases the cross appears equally blurred in both meridians; in astigmatic cases the vertical or horizontal blurred images reinforce each other, so that either the vertical row of squares or the horizontal row appear as blurred oblongs.

The important point brought out by Cohen is that the meridian most out of focus will always appear the blacker, due to the reinforcement above mentioned. This experiment can be considered analogous to the visual experiences of an astigmatic patient observing the chart. In order to intensify the reinforcement and contrast just referred to, the Cohen chart has been constructed of rectangles whose lengths have a 3:1 ratio to the widths and to the spaces between the rectangles. Each rectangle is designed to subtend at the patient's nodal point an angle of 2′ for the width and 6′ for the length. The result of this design is that when the cross is rotated from a position of coincidence with the principal meridians of the eye under test, the blurred areas cease to reinforce each other and the patient notices a marked change in the color and definition of the lines.

Cohen also suggests that this effect is further increased by projecting the cross lines on a monochromatic red background, thus eliminating chromatic blur circles. The selection of the red background permits the use of additional plus spherical power, as all eyes are *Relatively* hyperopic for red so that when the later steps of the test are taken the eye is

automatically fogged for white (or yellow) light.

This covers the theory underlying the chart itself. Next a discussion of the technique follows. The broken cross lines are set with the principal meridians coinciding with the principal meridians of the eye under test, as indicated, by the ophthalmometric or retinoscopic findings. If no astigmia is indicated, or if the findings are uncertain, the lines are set in a vertical-horizontal position (90°-180°). The patient's attention is directed to the chart and plus (or minus) spherical lenses are placed in the phoroptor or trial frame until the strongest plus or weakest minus lens is found with which the patient can see one of the cross lines "fairly clear" and the addition of more plus *blurs* BOTH lines. If both lines appear equally clear (or blurred) throughout this step of the test, the cross lines are rotated an angular distance of 45 degrees and if in this new position, they are still reported equally clear, or blurred, the absence of regular astigmia has been demonstrated. The cross cylinder check can be used, if desired, to prove the findings, in fact, this simple piece of apparatus nowhere demonstrates its value more fully than when used in conjunction with the technique suggested by Cohen. In those cases in which one line is reported by the patient as being blacker or clearer than the other, the cross lines are rotated an angular distance of 10 to 15 degrees, first to one side, then to the other side of the primary position and the patient is instructed to observe the CLEARER LINE and to report whether the blackness of the line increases or diminishes as it is rotated.

Cohen finds that because the blur circles are monochromatic, a change from a position of mutual reinforcement will produce a marked change in definition of the blacker line, so that most patients will be able to locate the position of "greatest blackness" with remarkable accuracy. It can be clinically demonstrated, he claims, that a trained observer with an astigmatic error of 0.50 diopter or more, can locate the axis of error within one degree upon repeated trials. With untrained observers of low intelligence such a high degree of accuracy is not claimed, but it will be found that even this group can locate the axis of error within five degrees. Once the principal meridians have been located, minus cylindrical correction is added until the lines are equally black (slightly blurred) and the addition of additional minus cylindrical correction causes the second line to appear blacker than the first.

The reader will have noted that, in the suggestions for locating the axis of the astigmia, the arguments frequently presented against consecutive comparison have been ignored. This has been made necessary by the fact that simultaneous comparison of small differences of stimulation of adjacent retinal areas tends to bring into play the factors of visual memory, attention, etc., previously referred to. Therefore the problem in this case is the selection of the lesser of two possible sources of error. It may be further stated that the change in definition of the

line, in astigmatic error, is so marked as to reduce greatly the keenness of judgment required, which adds also to the accuracy of the test.

B. Measurement of the Manifest Spherical Error and Balancing of the Monocular Findings.

The purpose of this part of the Cohen subjective technique is to measure the manifest spherical error and to balance the monocular prescription found, so that the final prescription may be found binocularly. It is now assumed that the astigmatic error has been corrected in the previous part of the technique, the Cohen targets for this step have been designed to avoid reinforcement of blur circles in the event that residual astigmia is present. They are further designed so as to present to the patient's attention simple elementary figures which contain no stimulation to visual memory, attention or accommodation and which will retain their identity of design through a wide range of blur and fogging.

The Cohen chart used for this phase of the technique consists of two pairs of targets, identical in design, and differing only in size. Each target consists of a smaller circle concentrically placed inside a larger circle. The smaller targets are designed so that, when projected or viewed the angular width of each circle at the nodal point of the patient's eye is 2′, the width of the space between the circles is 2′ and the entire figure subtends an angle of 16′. The larger pair of targets, which are used in amblyopic cases subtend angles 50 per cent greater than the smaller targets. Cohen suggests that the four targets be projected upon a background of two different colors, so that there is one large target and one small target upon each background. The colors of the backgrounds are red and green and are of such wave length that rays from distantly placed light sources of the respective colors will form equally sized blur circles upon the retina of an eye focused for yellow light. Obviously, the green blur circles are formed by rays that focus in the vitreous and proceed onward until they strike the retina; while the red blur circles are formed by rays directed to a point behind the retina and intercepted by it.

Now as is known an eye focused for white or yellow light is one-half diopter hyperopic for red light and one-half diopter myopic for green, it therefore is readily seen that if the target on the red background is sharply focused, the target on the green background will be one diopter out of focus, and conversely, if the target on the green background is sharply focused, the target on the red background will be one diopter out of focus. In other words, the chromatic aberrations of the eye may be utilized as a magnified scale for the measurement of the manifest error of refraction.

This test as devised by Cohen is an extremely sensitive and rapid one. Since the previous test was made with red light, the patient is slightly fogged for red and quite fogged for green at the commencement of

this step in the technique. The patient is directed to observe, monocularly, the two small targets, through the correction found in the previous test, and to state which target is more blurred. The correct and obvious reply is that the green target is more blurred. Concave spheres are added to the correction in the phoroptor or trial frame until the targets appear equally clear (in reality, equally blurred). The addition of a quarter of a diopter of minus sphere will cause the red target to appear more blurred (i.e., the green target will appear more clear). In many cases, only a twelfth of a diopter will be required to cause this reversal. This operation is then repeated for the other eye, the first eye being occluded, and constitutes the entire second step of this subjective technique. It might be pointed out that two important items of information are obtained from this phase of the test. First, the correction with which the patient reports both targets alike, or the green target clearer, is the correction with which the patient will obtain maximum visual acuity. Second, the refractive corrections for the two eyes have been balanced upon the same conditions, and a proper base from which to commence the binocular phase of the examination has been developed.

Now in addition to possessing the factual information above mentioned, the optometrist commences the third and final step of the examination under the following favorable conditions. First, no conventional test letters have been shown to the patient, except in the preliminary recording of the visual acuity, which it is assumed, is the first step in any well ordered examination. Second, although the patient has been given three opportunities to judge relative values, these judgments have been required under conditions carefully arranged to inhibit anxiety and fatigue and to stimulate interest. There is slight mental effort required to make the judgments requested, so that even the lower types of mentalities can give rapid answers. Furthermore, as pointed out by Cohen, the patient has no clue to the accuracy of his answers, and in fact, no suggestion that any other answer than that given is possible. Consequently, the anxiety often reported during the subjective test is entirely avoided.

Step C. Investigation of the Accommodative Activity.

The final step in the Cohen technique is to ascertain whether the visual acuity obtained with the prescription found in the previous step of the test is also obtained with the minimum accommodative effort. The apparatus used is a conventional letter or number chart. The technique is basically that of the conventional fogging test, with one modification. This modification is based upon the following fact. When the illumination, accommodation and size of the pupil remain constant, there is a direct relationship between the artificial myopia induced by fogging lenses and the retinal blur circles produced by the lenses and reflected in the lowered visual acuity, produced by these fogging lenses.

As Cohen points out, every text book of refraction contains some sort of table showing this relationship, and every refractionist has such

a table based upon his own refracting-room experience. While these tables agree in principle, they vary in detail due to the varying factors of size and design of the test letters used, illumination, etc. It is important that the conditions of the examination room, that is, the illumination of the test chart, extraneous illumination of the room, design of test letters, etc., be held constant for all examinations, so that the individual optometrist can correct the appended table according to his own working conditions, in his own refracting room.

Table

0.50 Fog should reduce 20/20 Visual Acuity to 20/30 Scant.
1.00 Fog should reduce 20/20 Visual Acuity to 20/50 Scant.

The technique of this portion of the test is as follows: The conventional letter chart is projected, and the patient asked to read the bottom row of letters or numbers, or the smallest row possible. (VA_1). The visual acuity is recorded (VA_1), + 1.00 spherical fogging lenses added and the visual acuity again recorded (VA_2). The fog is then reduced to +0.50 and the visual acuity with this correction recorded (VA_3). It may be stated that in the absence of marked myologic findings, a prescription giving 20/20 as VA_1; 20/50 scant as VA_2 and 20/30 scant as VA_3 will give maximum visual acuity with minimum accommodative effort and will be completely satisfactory.

The Cohen technique of subjective refraction is a decided step forward, as it placed this portion of a refractive routine on a par with the objective tests now in use. As has been said, the new technique eliminates the marked disadvantages of the older types of subjective testing, and at the same time gives the optometrist more accurate findings to compare with the findings obtained by means of the objective tests. Cohen has given this new technique to the refractive and scientific world. The tests mentioned have been in use in many offices for a considerable period of time. The technique has worked even better than he originally anticipated, and has proven itself to be an important factor in refracting room procedure.

Carel C. Koch.

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SPECIAL REPORT

KENTUCKY COUNCIL ON OPTOMETRIC EDUCATION AND PROFESSIONAL GUIDANCE CREATED*

H. K. Fulkerson, Opt.D.
Somerset, Ky.

In response to an invitation sent out to official members of The Kentucky Association of Optometrists by the State Director of Educa-

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tion to attend a meeting in the office of The Walden School of Optometry, at Mt. Sterling, Kentucky, the following were present: Dr. R. M. Kendall, Chairman, and Dr. E. H. Cornelison, Vice Chairman of The Kentucky State Board of Examiners in Optometry, Louisville; Dr. Starr E. Steele, Corbin, President, and Dr. R. O. Warren, Lexington, Secretary of The Kentucky Association of Optometrists; Dr. H. K. Fulkerson, Somerset, State Director of Education; Dr. W. D. Walden, Mt. Sterling, President of The Walden College of Optometry; Dr. H. E. Walden, Irvine, and Dr. Tracy Wallace, M.D., Irvine, Directors of The Walden College; Hon. W. C. Hamilton, Mt. Sterling, Attorney for The Walden College.

Dr. Fulkerson made a brief talk in which he imparted the information he had obtained on a recent trip to Philadelphia and Baltimore where he had conferences with Dr. Albert Fitch, President and Dean of The Pennsylvania State College of Optometry, and Dr. Fred Andreae, Secretary of the I. B. B., and Dr. B. Woodard Hazell, Chairman of the Committee on Education of the I. B. B. At the conclusion of his talk, the Kentucky Council on Optometric Education and Professional Guidance was formed for the purpose of inspecting the Walden College of Optometry and Technology, and if found worthy, to approve same.

The pamphlet on "Requirements for Optometry Schools" sent out by The International Associations of Boards of Examiners in Optometry was used as a guide and each of the fourteen requirements were discussed at length; after which the school was inspected relative to faculty, curriculum and equipment. It was the unanimous opinion of the Council that this school was adequately meeting the requirements set up by the I. B. B. and was thereby accredited by the Council and given an "A" rating for Kentucky. The Council is sure that this school will have no difficulty in obtaining an "A" rating from the I. B. B. as soon as they have their first graduating class, which is a requirement of the I. B. B.

The Council on Optometric Education and Professional Guidance is composed of the president, vice president and secretary of the K. O. A., the chairman, vice chairman and secretary of the Board of Examiners in Optometry, and the three members of the Educational Committee of the K. A. O. with the State Director of Education as Chairman of the Council.

No doubt Kentucky has established a precedent by creating a State Council on Optometric Education and Professional Guidance, and the accrediting of an Optometric College, but by so doing we feel that it is the most forward step this state has ever taken. There is no question but what Kentucky needs a school of this kind, and we hereby quote from the minutes of the annual meeting of the International Associations of Boards of Examiners in Optometry at Rochester, N. Y., July 1, 1937, part of a discussion between Dr. W. B. Needles, President of The Northern Illinois College of Optometry, and Dr. B. Woodard Hazell, Chair-

man of the Educational Committee of the I. B. B.:

DR. NEEDLES SAID: "It is highly important to give a school a rating of 'A.' It is practically impossible to give a school that rating unless it is in position to measure up in a multitude of particulars, physical equipment, quality and number on the faculty, the character of the course, the nature of the entrance requirements, and many other matters. In order to measure up to these things it means a very considerable investment. There are certain communities where it will be impossible for such a school to be established except on some kind of endowment basis such as I have not heard of being available to any of the schools.

"On the other hand, those communities need optometrists. They can acquire optometrists well trained, men who are competent to pass the boards and who can render fine service and will help promote optometry.

"Now we have seen the situation where we have great numbers of states with only one or two schools serving that whole large group. I am not so sure that optometry would not be better served if it were possible for a few additional smaller schools, under good management, to come into the field and exist and render their service in those communities."

DR. HAZELL SAID: "It is not right that a school with thousands of dollars worth of equipment should be compared with a small school which does not need so much equipment. If that small school had sufficient laboratory equipment and sufficient teachers for the number of students and in every respect met each condition that the larger schools met, that small school would be entitled to an 'A' rating just the same."

And now that we have a candid expression from two great men in optometric education, Drs. Needles and Hazell, we feel very much encouraged and elated over the outlook of our Kentucky Optometric school, and The Kentucky Council on Optometric Education and Professional Guidance will see to it that The Walden College of Optometry will meet the I. B. B. requirement as far in as possible and will not bring discredit upon the optometry schools or the profession of optometry in our country. The name of The Walden College of Optometry and Technology will be changed to THE KENTUCKY STATE COLLEGE OF OPTOMETRY in the near future. The faculty and laboratory equipment will also be increased and improved, and as soon as the school is financially able it will be moved to Louisville or Lexington.

DR. H. K. FULKERSON
SOMERSET, KY.

BOOK NOTICES

THE EXTERNAL DISEASES OF THE EYE. Donald T. Atkinson, M.D., F.A.C.S. Second Edition. Published by Lea & Febiger, Washington Square, Philadelphia, Pa. 718 pages. 494 illustrations. Cloth $8.00. 1937.

Three years ago the first edition of this work appeared. This text met with such immediate response that the second edition has already made its appearance. Atkinson, in this revised new book, again presents the matter of diagnosing the external diseases of the eye in a clear and understandable manner. The text is well illustrated and the work is so indexed as to make it a ready reference work. C. C. K.

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OUTLINE OF OCULAR REFRACTION. J. T. Maxwell, M.D. Published by the Medical Publishing Company, Medical Arts Building, Omaha, Nebr. 395 pages. Illustrated. Cloth $7.50. 1937.

Maxwell takes his ocular refraction seriously and the book he has just written is a nicely gotten together review of the major steps which should be taken by all eye men attempting to do this work. This new book is not padded out with a mass of material from the field of geometric optics as are so many texts dealing with this specialty and for this we may be thankful, although the subject is well covered in the first chapter. The other chapters deal with the physiology of vision, various instruments used in diagnosis and refraction and their use as well as a complete review of a refraction routine in which the author goes into minute detail showing each step of the procedure under discussion. This work has a very definite place in our literature and the author has made a worthwhile contribution to our general sum of knowledge. Written as it is by an ophthalmologist it is pleasing to note that considerable space is given to the dynamic skiametric technique, wherein the procedure as suggested by Edwin Forbes Tait is used as basic. All portions of our work are well handled and the book will be found to be of considerable interest to all optometrists. C. C. K.

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DISEASE OF THE EYE. By Charles H. May, M.D. Published by William Wood & Co., Baltimore, Md. Fifteenth Revised Edition, 498 pages, 376 illustrations, 25 plates and 78 colored figures. Cloth binding. Price $4.00. 1937.

"Disease of the Eye" by May is the most widely used manual on this subject, not only in the United States but in the world. More than

a quarter of a million copies have been printed and distributed to date. The first edition came off the press in August, 1900. Since then, this book has been reprinted 38 times in the United States and of these printings 14 were revised editions. It was reprinted 15 times in Britain. It has been translated in many languages and printed and reprinted in many foreign countries as follows: In Spanish, nine times, in French, Italian, Dutch six times each, German and Japanese two times, and in Chinese three times.

A record like this speaks for itself and leaves little for comment for the reviewer. This book is the most complete treatise on this subject, and is of particular value to the busy practitioner medical or optometric. The subject matter is arranged so systematically, that one can get the desired information with the least expenditure of time and effort. The author intended to say enough on each subject and not too much. This he accomplished.

It contains much valuable information for the optometrist to help differentiate between the normal and abnormal, between the physiological and pathological conditions. The last chapter on the ocular manifestations of general diseases is particularly to be recommended as it contains valuable information.

This book should find a place not in the library of every optometrist, but in his refraction room. J. I. K.

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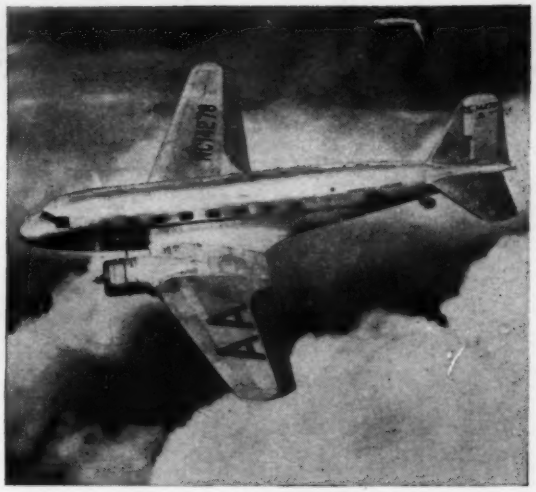

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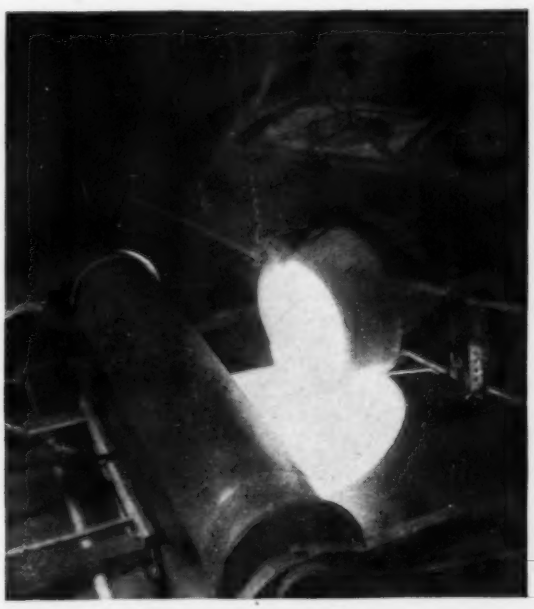

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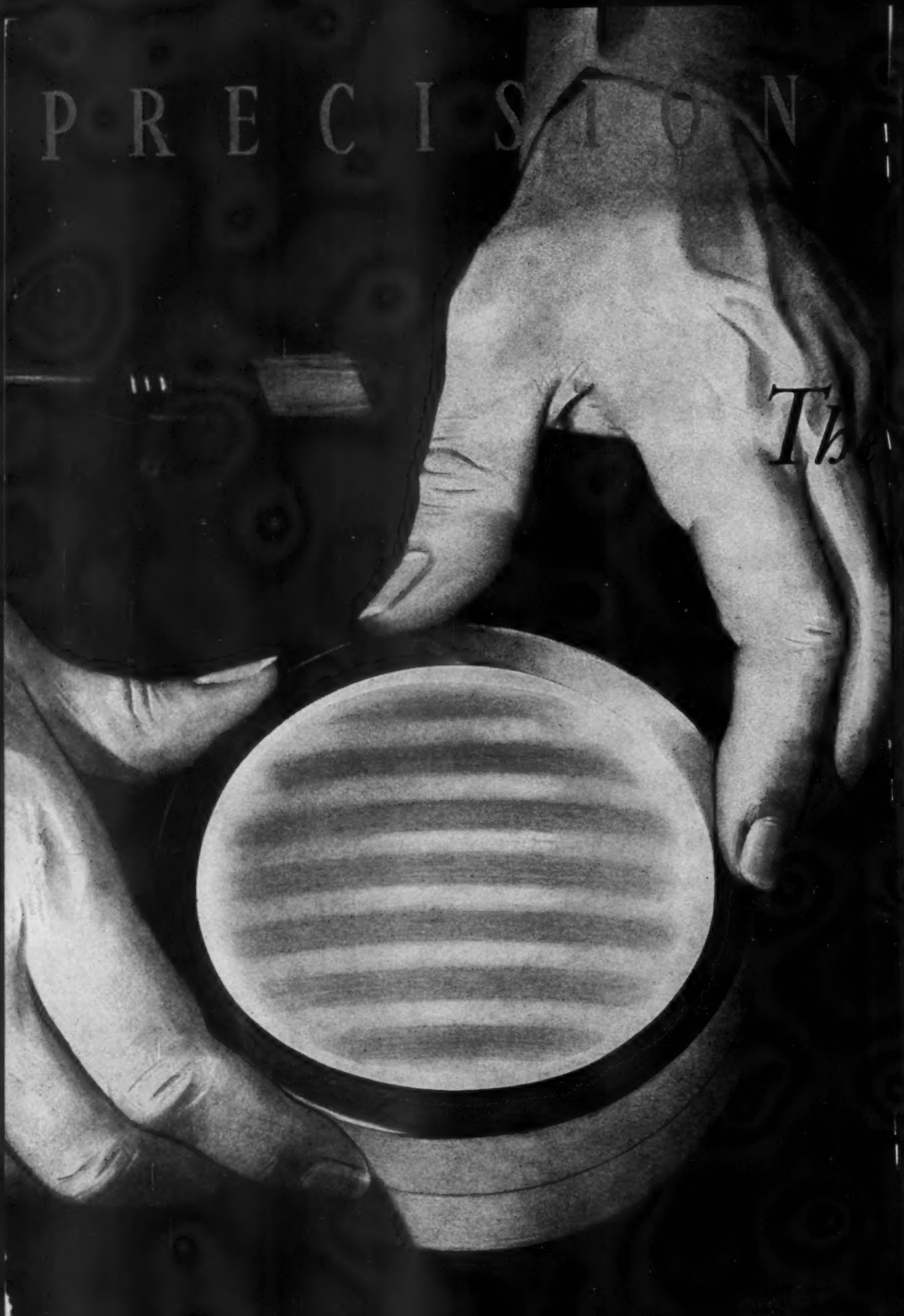
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